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CLINICAL COMMENTARY

HIP MUSCLE INHIBITION AFTER HIP ARTHROSCOPY: A ROLE FOR NEUROMUSCULAR ELECTRICAL STIMULATION

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ABSTRACT

Background/Purpose: The number of hip arthroscopies (HAs) performed in the United States is increasing exponentially. Previous authors have shown improvements in short- and mid-term functional outcomes after HA. Despite established overall improvements, functional and objective impairments may persist. In particular, preliminary work demonstrates differences in hip strength between patients who undergo HA when compared to healthy controls at 12- and 24-months post-operative. The purpose of this clinical commentary is to highlight the persistent hip muscle strength and neuromuscular deficits that occur after HA, as well as propose the utilization of neuromuscular electrical stimulation (NMES) as an adjunct to strengthening exercises in early post-operative rehabilitation to address deficits.

Description of Topic: Arthrogenic muscle inhibition (AMI), drives neuromuscular dysfunction and has been shown to occur in peripheral joints. The knee and hip have historically benefited from NMES to aid in improved muscular function, such as in those who have undergone anterior cruciate ligament reconstruction, total hip or knee arthroplasties. Improving muscular strength is a hallmark component of rehabilitation after HA, however, current post-operative HA rehabilitation protocols do not include NMES as a standard treatment intervention. Therapeutic intervention strategies to target muscular inhibition after HA, in particular with the goal to address neural reflex inhibition, have not been thoroughly investigated. This absence of understanding of this important problem yields a critical gap in the treatment of post-operative muscular deficits in patients after HA.

Discussion: The consequence of hip muscle inhibition is likely to include deficits in strength and function, similar to that seen in other muscular groups. Filling the void of current knowledge with regard to muscle inhibition and strength deficits after hip arthroscopy is critical to establish standardized post-operative rehabilitation protocols, as well as to provide targeted training to address muscular inhibition. Ultimately, these strategies could produce improved outcomes guided by robust evidence-based protocols.

Level of Evidence: 5

Key words: hip arthroscopy, movement system, neuromuscular electrical stimulation

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BACKGROUND AND PURPOSE

The number of hip arthroscopies (HAs) performed in the United States increased nearly six-fold from 2004 to 2009.[1] The incidence of hip arthroscopy (HA) in the United States continued to rise in 2007 through 2014.[2] HA addresses a constellation of injuries and associated surgical procedures including labral debridement and repair, correction of cam and pincer morphology seen in femoroacetabular impingement syndrome (FAI), chondroplasty, osteoplasty, microfracture, synovectomy, repair of the ligamentum teres, treatment for capsular hyperlaxity, and loose body removal.[3] Recent advancements in clinical examination skills and diagnostic imaging have yielded a large increase in the recognition of non-arthritic, intra-articular hip pathologies. Thus, there is a critical need to provide outstanding post-operative care in order to maximize patient outcomes after HA.

Previous authors have shown functional outcome improvements in short- and mid-term patient follow ups after HA.[4] A review by Khan et al analyzed pooled data from 104 studies aimed to quantify short and midterm clinical outcomes after HA.[4] This review identified post-operative functional improvements, in comparison to preoperative baseline, using several outcome measures, including the modified Harris Hip Score (mHHS), Hip Outcome Score (HOS), Non-Arthritic Hip Score (NAHS) and Visual Analog Scale (VAS) up to 24 months postoperative.[4] Ten year follow ups using the modified mHHS also demonstrate improvements in pain and function.[5,6]

Rates of return to sport after HA are high.[7,8] Memon et al completed a systematic review to assess return to sport rates after HA.[7] This review included 38 studies and 1,773 patients with a mean age of 28 years old.[7] Mean return to sport rate was 93% in this cohort which included recreational, competitive and professional athletes returning to several different sports.[7] O'Connor et al completed a systematic review and meta-analysis aimed to determine mean return to play duration and return to sport rate.[8] Their analysis included 22 studies and 1,296 patients which included recreational through elite level athletes returning to different sports with a mean age of 40 years.[8] In this older cohort, the mean duration for return to play was 7.4 months and the mean return to sport rate was lower than the previous cohort at 84.6%.[8]

Despite established subjective improvements, functional and objective impairments may persist after HA. Kemp et al used the Hip disability and Osteoarthritis Outcome Score Quality-of-life subscale (HOOS-Q) and the International Hip Outcome Tool (iHOT-33) to demonstrate that even eighteen months after HA, patients reported lower quality of life in self-reported outcome measures when compared to healthy controls.[9] Preliminary work also demonstrates deficits in objective and modifiable physical measures, including hip strength and active range of motion in patients who undergo HA when compared to healthy controls at 12 and 24 months post-operative.[9,10] Regarding active range of motion, Kemp et al found that patients 12-24 months after HA demonstrated decreased active hip internal rotation range of motion as assessed with an inclinometer, in comparison to healthy controls.[10] Additionally, those after HA demonstrated decreased hip adduction, extension, flexion, internal and external rotation isometric strength peak torque normalized to body weight when assessed with a hand held dynamometer.[10] This suggests that long term deficits persist post-operatively.

These lower performances on objective measures and functional, self-reported outcomes may be related. Kemp et al revealed that greater hip flexion range of motion and adduction strength were associated with better scores on the HOOS-Q and iHOT-33 in patients 12- to 24-month post-arthroscopy.[9] Moreover, these modifiable physical measures exhibited a stronger association with the HOOS-Q and iHOT-33 scores in comparison to non-modifiable measures including older age, joint space narrowing and more severe chondropathy which are commonly associated with poorer outcomes.[9]

Muscle impairments are also commonly present pre-operatively. Isometric and isokinetic strength testing demonstrate that patients with symptomatic labral tears also display significantly decreased maximum voluntary contraction strength with hip flexion, abduction, adduction and external rotation in comparison to healthy controls.[1,4] Pre-operative dysfunction may relate to post-operative impairments.

Overall, patients who undergo HA experience a protracted period, including pre and post-operative care, of muscular dysfunction and associated muscular weakness.[9–11]

The purpose of this clinical commentary is to highlight the persistent hip muscle strength and neuromuscular deficits that occur after HA, as well as propose the utilization of neuromuscular electrical stimulation (NMES) as an adjunct to strengthening exercises in early post-operative rehabilitation to address deficits.

DESCRIPTION OF TOPIC WITH RELATED EVIDENCE

Injury and surgical intervention result in physical impairments, as illustrated in Figure 1. The goal of rehabilitation is to implement reliable strategies which effectively resolve these impairments. The current body of the literature in regard to HA post-operative rehabilitation protocols is largely based on clinical experience and lacks standardization.[3,4,12,13] While there is a common consensus regarding early post-operative rehabilitation goals as shown in Figure 2, these protocols are void of objective performance standards to guide patient progression after HA. Multiple authors have cited the need for continued research on the management of HA in order to establish evidence-based protocols.[3,4,11–16]

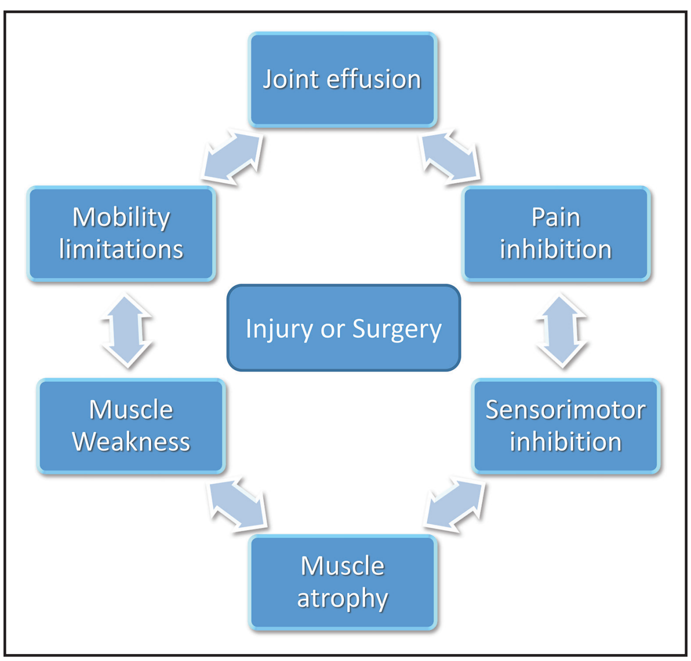

Figure 1. *Physical impairments which result from an injury or surgery.*

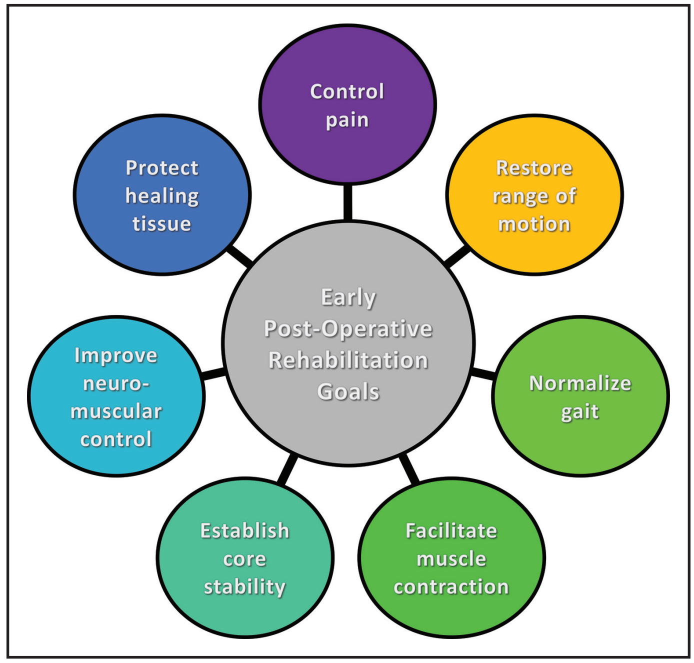

Figure 2. *Early post-operative rehabilitation goals after HA.*

Physical impairments in patients with hip pain are well documented. Neuromuscular adaptations exist in patients with symptomatic labral pathology.[11,17] Patients with symptomatic femoroacetabular impingement demonstrate decreased electromyography (EMG) activity in the gluteus maximus in comparison to healthy controls when performing the ascent phase of a lunge.[17] Symptomatic patients also demonstrate significantly decreased EMG activity in the tensor fasciae latae with active hip flexion.[11] The presence of these alterations in neuromuscular activation warrants further investigation.

Numerous authors have demonstrated significant strength deficits, ranging from 11-28% in comparison to asymptomatic controls in the hip abductors, flexors, external rotators and hip adductors muscles, in patients with symptomatic femoroacetabular impingement.[11,15,18,19] Preliminary studies indicate that strength impairments persist after HA. Kemp et al found that patients who underwent HA 12-24 months prior, achieved significantly decreased muscular strength in hip flexion, extension, abduction (women only) and adduction in comparison to healthy controls.[10]

The mechanism causing these deficits as well as the temporal relationship are not yet well understood. Investigators have determined that pain inhibition, muscle atrophy, mechanical/anatomic limitations and muscular activation deficits as potential contributors to deficits in muscular activation and strength.[11,15]

Arthrogenic muscle inhibition (AMI), which contributes to neuromuscular dysfunction, is described as an inhibition in a neural reflex inhibition in which the central nervous system is unable to completely activate a muscle.[20–22] This phenomenon most commonly occurs in muscles surrounding peripheral joints in the setting of intra-articular injuries, surgical intervention, or joint distension.[21,22] Overcoming AMI is a rehabilitation challenge and can be a barrier to therapeutic advancements.[23] Immediate consequences of muscular inhibition include impaired strength development and compromised healing capacity.[21,22] Long term consequences include persistent deficits in muscular strength and neuromuscular control which can result in an inability to return to normal function and early onset osteoarthritis.[21–23] Figure 3 identifies the consequences of AMI.

Similar to that which commonly occurs in the knee, AMI also occurs at the hip joint.[21] Freeman et al demonstrated that peak gluteus maximus EMG values decreased significantly in patients with hip pathology when performing supine bridge and prone hip extension following injection of intra-articular fluid. The joint distension and subsequent AMI caused by the injected fluid is comparable to that which occurs with hip joint injuries and subsequent joint effusion. These findings indicate that hip joint effusion is a contributor to gluteus maximus inhibition.

Figure 3. *Evidence based consequences of arthrogenic muscle inhibition.*

The consequence of hip muscle inhibition is likely to include deficits in strength and function, similar to that seen in other muscular groups. The inhibition of hip muscles after hip injury is an important clinical consideration. The current body of literature, however, has not evaluated the presence of AMI in patients after HA nor specific therapeutic strategies to address these deficits.

Restoration of muscular strength is of paramount importance in post-operative rehabilitation. Lower extremity (LE) strength correlates with function in patients who have undergone orthopedic surgery, including anterior cruciate ligament reconstruction, total hip and knee arthroplasties as well as HA.[9,24,25] Therefore, improvements in strategies implemented to gain muscular strength may also lead to higher functional outcomes.

Muscular strengthening is a hallmark component of rehabilitation after HA. Prior to achieving strength gains, muscular inhibition must be addressed. The current body of literature identifies early post-operative rehabilitation goals to include improving muscular activation, preventing muscular inhibition, re-educating correct firing patterns and motor function.[12,14,16,26–28] Phase I protocols consistently utilize various isometric hip strengthening strategies to target muscular activation. Throughout rehabilitation, muscular strengthening is strategically progressed from isometric to isotonic strengthening addressing hip, core and LE musculature, advancing ultimately into functional and activity specific strengthening. Strength gains, however, will be limited without specific strategies to reduce muscular inhibition. Additional therapeutic intervention strategies to target muscular inhibition, in particular with the goal to address neural reflex inhibition, have not been thoroughly discussed.

NMES: HISTORICAL UTILITY AND AS A PROPOSED INTERVENTION AFTER HA

NMES has been used for decades to increase the recruitment and strength of both healthy and compromised skeletal muscle.[29] NMES augments volitional recruitment by applying electrical current over muscles and nerves to produce muscle contractions.[30] NMES is used in many settings as an adjunct to exercise. In the neurologic setting it is often used in patients with cerebral palsy to facilitate gait. In orthopedic and sports rehabilitation, NMES is used in the post-operative environment as an adjunct to exercise to aid in reversing the negative effects of AMI and facilitate improved muscular activation, strength, and function.[31]

When using NMES in patients with musculoskeletal pathologies, both operative and non-operative, there is no consensus regarding treatment protocol.[31] Variability can exist in multiple parameters, including electrode placement, stimulation parameters, as well as treatment schedule.[30] Despite this variability, a few common principles exist. NMES is consistently shown to be most valuable in patients who demonstrate voluntary activation failure.[31] Treatment protocols are consistent in that high volume treatments, in which NMES is completed at least daily, is most effective.[31]

A recent current concepts review by Spector et al proposes a two phase criteria based algorithm for NMES therapy aimed to restore quadriceps voluntary activation and muscle strength after orthopedic surgery.[31] Following a one to two week period of NMES familiarization, patients complete phase one which is characterized by high intensity and high volume NMES.[31] After about three weeks, the patient is reassessed, and if volitional activation failure still exists, the patient proceeds to Phase 2 which is characterized by high intensity and low volume NMES for approximately three weeks.[31] Finally, the patient is progressed to voluntary strengthening.[31] The purpose of this review was to provide clinicians an algorithm to optimize and simplify clinical application of NMES.[31]

Given the utility of NMES in aiding improved muscular function in quadriceps function a review of the literature was completed to evaluate the utilization of NMES to restore hip muscle function after HA, in order to inform the current clinical commentary. None of the 968 articles in the search utilized NMES in hip muscles or in patients following HA and therefore none met inclusion criteria. Thus, a review of the literature determined that this aspect of muscular inhibition demonstrates a critical need to pursue in future studies. While NMES can be a useful tool in aiding improved muscular function in those who have undergone ACLR, total hip arthroplasty and total knee arthroplasty, there are currently no studies which utilize NMES to enhance hip strength or evaluate the effects of NMES in patients after HA. Furthermore, current post-operative HA rehabilitation protocols do not include NMES as a standard treatment intervention.[14,16,28,32,33] Therefore, the relationship between muscular dysfunction and the efficacy of NMES in patients after HA is unclear. This absence of understanding of this important problem yields a critical gap in the treatment of post-operative muscular deficits in patients after HA. At this time, specific recommendation for utilization of NMES on hip muscles in patients after HA are undefined.

DISCUSSION

Filling the current knowledge void with regard to hip muscle inhibition after HA is critical to establish standardized post-operative rehabilitation protocols and optimize patient outcomes; particularly with the recent increase in HA. Subsequent EMG studies could be implemented to evaluate hip muscle volitional activation serially and longitudinally throughout the post-operative interval. Studies that quantify the level of volitional muscle activation with strength testing as well as functional tasks could provide objective insight into the state of muscular activation patterns in post-operative patients.

Further investigation into effective treatment strategies which can address hip muscle deficits is also needed. The effectiveness of NMES has been studied extensively and has shown to be a useful tool to improve strength and performance in post-operative setting.[34–37] NMES is commonly applied to the quadriceps muscle after anterior cruciate ligament reconstruction (ACLR), total hip arthroplasty and total knee arthroplasty.[35] Additionally, previous studies have shown NMES used in adjunct with physical therapy produces greater gains in quadriceps strength, in comparison to therapy alone, after

ACLR.[35] Numerous studies demonstrate strength and function improvements in operative and non-operative musculoskeletal conditions after the use of NMES.[30] While NMES is thought to be one of the most effective treatment methods for arthrogenic muscle inhibition, the current body of literature does not yet describe its use with patients after HA.[31] Studies which assess the ability of NMES to improve volitional hip muscular activation could provide further direction for effective rehabilitation strategies. This result may provide insight to guide rehabilitation interventions after HA to facilitate muscular strength gains.

There is a critical need to investigate the status of hip muscular activation and the effects of NMES in patients after HA. Continued research will result in improved understanding of patterns of recovery after HA. Furthermore, future studies may provide insight into effective therapeutic interventions strategies to enhance post-operative strength function and outcomes. As a result, rehabilitation specialists will be able to develop and utilize evidence-based treatment protocols that address patients' persistent post-operative impairments.

CONCLUSIONS

The current body of literature has not evaluated the presence of AMI in patients after HA nor presented specific therapeutic strategies to address these deficits. Consequently, current evidence-based rehabilitation protocols are incomplete without addressing these potential muscular activation deficits. Future clinical studies which assess hip muscles activation and effective treatment strategies are needed. Identification of post-operative deficits as well as methods for improvement will fill a critical void for rehabilitation of patients after HA. As research regarding recovery after HA progresses, rehabilitation specialists will be better informed to provide targeted training to address muscular inhibition to ultimately produce improved outcomes guided by robust evidence-based protocols.

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